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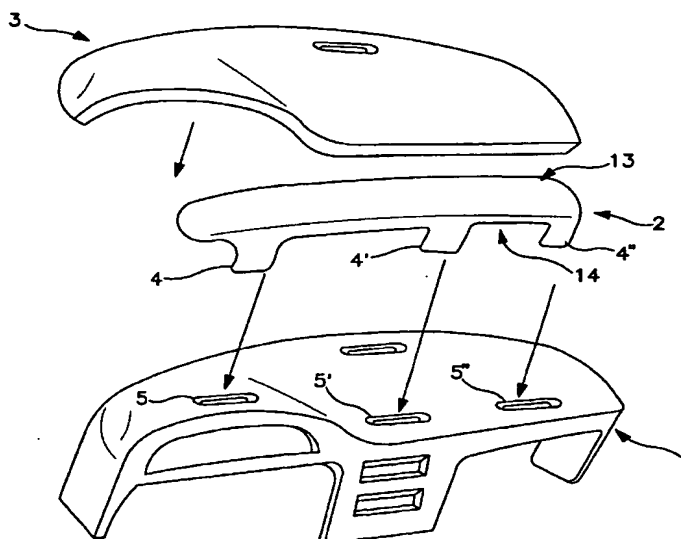
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[Continued on next page]

(54) Title: INTEGRATED DUAL FUNCTION CIRCUITRY AND ANTENNA SYSTEM



(57) Abstract: A trim panel for a vehicle containing a vehicular antenna system comprising a substrate, an outer skin and a foam disposed between the substrate and the outer skin. An antenna/circuitry system (2) is located on the upper surface of the substrate (1) and is in contact with the urethane foam (7), the antenna/circuitry system (2) comprising an insulating base layer (12) including upper and lower surfaces and an electro-conductive antenna layer on the upper surface of the base layer (12) and an electro-conductive circuit layer on the lower surface of the base layer (12).

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**INTEGRATED DUAL FUNCTION CIRCUITRY  
AND ANTENNA SYSTEM**

**Field of the Invention**

This invention relates to an integrated antenna system suitable for vehicular use. In such regard, a complete vehicle antenna system is disclosed that can be integrated with one or more other vehicle components and, in particular, with interior components such as the instrument panel. The invention also relates to an antenna system which is integrated with a flexible printed circuit or other flat wire which replaces current wire harness construction (i.e. with round wire) in providing an electrical circuit routing electric current between one or more connected electrical devices. Such an antenna with the flexible printed circuit may also be integrated with one or more other vehicle components and, in particular, with interior components such as the instrument panel.

**Background of the Invention**

In general, two forms of automotive antennas find widespread use, i.e., the mast antenna and the windshield antenna. The mast antenna comprises a rod conductor projecting from the vehicle body. It is fairly well established that the mast antenna is subject to deterioration, by exposure, is prone to damage from external objects, and is easy prey for vandals. Further, mast antennas may detract from the aesthetic appearance of the vehicle. Of course, the mast antenna may be powered to retract, which adds cost to the vehicle.

Windshield antennas make use of one or more thin conductors embedded within the windshield of the automobile. Windshield antennas are also susceptible to

1 their own problems, such as unnecessary replacement simply because the glass has  
2 been damaged. In addition, windshield antennas are reportedly susceptible to various  
3 forms of FM distortion, such as "station swapping" and may be sensitive to the  
4 direction of vehicle travel. Moreover, operation of the windshield washers may create  
5 undesirable effects upon the performance of a windshield antenna including the  
6 generation of noise. Furthermore, by mounting the antenna on the exterior or interior  
7 of the vehicle as separate components or integrating the antenna into window glass, a  
8 need is developed to route antenna cables between the electronic component and the  
9 antenna location. Such antenna cable is typically installed and connected by the auto  
10 manufacturer during assembly of the vehicle.

11 In related context, current vehicle electrical systems also require the  
12 manufacturer to route a wire harness throughout the vehicle body, and more  
13 specifically, through the instrument panel cockpit system. Such wire harnesses are  
14 generally bulky, expensive, heavy, difficult to install and often a source of a variety of  
15 warranty problems.

16 Attention is directed to the following U.S. Patents and the art cited therein to  
17 provide an even broader consideration of the variety of problems and solutions that  
18 have been proposed to date to improve upon antenna placement and/or wiring within  
19 an automotive environment: U.S. Patent No. 3,896,448 "Instrument Panel Radio  
20 Antenna"; 4,758,166 "Concealed Radio Antenna"; 4,853,793 "Microstrip Antenna  
21 with Stripline And Amplifier"; 5,811,732 "Modular Wiring System for Vehicle  
22 Instrument Panel Wire"; 5,861,857 "Vehicular Windshield Wiper Antenna System";

1 6,081,239 "Planar Antenna Including A Superstrate Lens Having An Effective  
2 Dielectric Constant"; and 6,144,343 "Display Antenna Center".

3 It is therefore an object of this invention to provide a remedy to the problems  
4 noted above in addition to the development of an vehicular antenna system that  
5 provides some unique advantages not reported in the prior art to date.

#### 6 Summary of the Invention

7 A trim panel for a vehicle containing a vehicular antenna system comprising a  
8 substrate,  
9 an outer skin and a foam disposed between the substrate and the outer skin. An  
10 antenna/circuitry system is located on the upper surface of the substrate and is in  
11 contact with the urethane foam, the antenna/circuitry system comprising an insulating  
12 base layer including upper and lower surfaces and an electro-conductive antenna layer  
13 on the upper surface of the base layer and an electro-conductive circuit layer on the  
14 lower surface of the base layer.

#### 15 Brief Description of the Drawings

16 These and other objects, features and advantages of the invention will become  
17 apparent upon consideration of the description of the invention and the appended  
18 drawings in which:

19 **Figure 1** is a representative exploded perspective view of an exemplary  
20 vehicle instrument panel which contains the invention.

21 **Figure 2** is a representative cross-sectional view taken through the  
22 antenna/circuit system.

1           **Figure 3** is a representative cross-sectional view of one type of instrument  
2 panel construction of the invention.

3           The above and other objects, features and advantages of the present invention  
4 will be apparent in the following detailed description thereof when read in conjunction  
5 with the appended drawings wherein the same reference characters denote the same or  
6 similar paths throughout the several views.

7                               Description of the Preferred Embodiments

8           For elements common to the various embodiments of the invention, the  
9 numerical reference character between the embodiments is held constant, but  
10 distinguished by the addition of an alphanumeric character to the existing numerical  
11 reference character. In other words, for example, an element referenced at **10** in the  
12 first embodiment is correspondingly referenced at **10A**, **10B**, and so forth in  
13 subsequent embodiments. Thus, where an embodiment description uses a reference  
14 character to refer to an element, the reference character applies equally to other  
15 embodiments as distinguished by alphanumeric character.

16           Attention is now directed to **FIG. 1**, which best illustrates a preferred  
17 embodiment of the subject invention. As shown therein, the rigid substrate **1** is  
18 designed to accommodate the dual-function antenna/circuitry system. The dual-  
19 function antenna/circuitry system **2** is then mounted on the rigid substrate, followed by  
20 incorporation of the skin/foam layer **3** to form the instrument panel. In this manner,  
21 the dual-function antenna/circuitry system is retained as to not rattle and comply with  
22 NVH (noise, vibration, harshness) requirements and BSR (buzz, squeak, rattle)  
23 requirements.

1           As can be seen, the upper (topside) surface 13 of the antenna/circuitry system  
2   2 comprises the antenna array, suitable for reception of radio transmissions, cellular  
3   phone frequencies, global positioning systems (GPS) and other miscellaneous  
4   transmissions, such as locking/unlocking signals, keyless ignition, alarm, wireless  
5   internet access, etc. Placement of the antenna array on the upper (topside) surface  
6   maximizes the efficiency of signal reception. On the bottom side 14 of the  
7   antenna/circuitry system 2 is located the electro-conductive circuitry which would  
8   replace all or part of the electrical wire harness that supplies power in the vehicle  
9   dashboard area.

10           Inclusion of flexible printed circuitry into vehicle interior trim panels is  
11   disclosed in U.S. Patent Application Serial Nos. 09/625,113 and 09/625,117 to the  
12   same assignee as this invention and are incorporated herein by reference.

13           Trim panels are generally multi-layered components formed by a variety of  
14   processes including but not limited to, injection molding, blow-molding, lamination,  
15   foaming-in-place, thermoforming, etc. The preferred construction consists of a  
16   skin/foam/substrate construction as shown in **FIGS. 1** and **2**. To include the  
17   antenna/circuitry system of the present invention into a trim panel of this type, the  
18   antenna/circuitry system 2 is attached to or through the instrument panel substrate 1 by  
19   adhesive or other mechanical attachment means known to those skilled in the art. The  
20   antenna circuitry system 2 may also be fitted into a slightly recessed area of the top  
21   surface of the substrate 1 for attachment and location. Alternatively, as shown in  
22   **FIG. 1**, extensions 4, 4' and 4'' of the antenna circuitry/system 2 may be provided to  
23   include connectors (not shown) which are passed through slotted openings 5, 5' and

1 5" in the substrate which also serve to locate and attach the antenna circuitry system  
2 to the substrate.

3 The connectors (not shown) are used to connect the antenna and electrical  
4 circuitry to the radio and other electrical devices in the cockpit area of the vehicle. As  
5 shown in FIG. 1, typical locations include, but are not limited to, the  
6 speedometer/gauge area 5 and the passenger side air bag area 5". For connection to  
7 the radio through slot 5', the antenna electro-conductive layer 13 can be configured  
8 such that the impedance for the receiver and antenna match, minimizing power loss.

9 The antenna/circuitry system is included in the construction of the instrument  
10 panel 20 in a manner known to those skilled in the art, by mounting the substrate 1  
11 containing the antenna/circuitry system 2 to the lid of a foaming mold, placing a skin  
12 6 (see FIG. 3) into the corresponding cavity of a foaming mold and dispensing  
13 urethane foam precursor between the substrate 1A and skin 6. The foam precursor  
14 expands to fill the cavity between the skin and substrate at least partially or fully  
15 encapsulating the antenna/circuitry system 2B in a cellular foam layer 7. In FIG. 3,  
16 the antenna/circuitry system 2B is on the surface of the substrate 1A, and in contact  
17 and/or embedded in the urethane foam 7. It can therefore be appreciated that the foam  
18 layer 7 in contact with the antenna/circuitry system 2B can serve to immobilize and  
19 locate the antenna/circuitry system in a convenient manner.

20 As alluded to above with respect to the use of a recess in the top surface of the  
21 substrate, other constructions may include thermoforming a grained skin/foam  
22 laminate directly over the substrate in which the antenna/circuitry system has been  
23 counter-sunk into a corresponding groove or shallow depression on the surface of the



1 substrate. In this manner the antenna/circuitry system substantially fills in the groove  
2 or depression to yield a substantially smooth surface over which the skin foam  
3 laminate can be formed. Polymeric materials are preferred for the skin 6, foam 7 and  
4 or substrate 1A, as they are substantially transparent to electromagnetic radio wave  
5 energy. Such polymer materials for the skin 6 include polyurethanes and poly(vinyl  
6 chloride) type materials. Suitable polymer materials for the foam layer also include  
7 the polyurethanes. The substrate may be prepared from acrylonitrile-butadiene-  
8 styrene (ABS) type materials, and blends thereof with materials such as  
9 polycarbonate.

10 Turning to FIG. 2, the construction of another preferred antenna/circuitry  
11 system 2A is shown. The system comprises a multilayer structure which includes a  
12 base layer 12 made up of an insulator such as a polyimide, a first antenna pattern layer  
13 13 comprising an electro-conductive film, such as a copper film, formed on the upper  
14 side of base layer 12 and a first circuit pattern layer 14 comprising an electro-  
15 conductive film, such as a copper film, formed on the lower side of base 12, a first  
16 cover layer 12' made up of an insulator such as a polyimide located on the upper  
17 surface of the antenna pattern layer 13 and a second cover layer 12'' made up of an  
18 insulator such as a polyimide located on the lower side of circuit pattern layer 14.

19 In accordance with the above, it can be appreciated by those of skill in the art  
20 that the use of a base layer 12 of polyimide, and a first antenna pattern layer 13  
21 comprising copper film, and a first circuit pattern 14 also of copper film, creates a  
22 flexible antenna/circuitry system in the sense that such system can be flexed without  
23 disrupting the conductivity and performance of the copper film and will readily

1     configure and locate on the upper surface of a vehicle substrate. In such regard, the  
2     antenna/circuitry system herein can alter its shape to adjust to the varying contours of  
3     a trim panel substrate, and then be uniquely immobilized on the substrate, when  
4     positioned under the instrument panel skin layer and within the foam layer, as  
5     previously described.

6             In yet other methods of integration, the dual purpose electrical and antenna  
7     system could be fastened (e.g. mechanically) or bonded (e.g. adhesive, welded) or  
8     otherwise affixed or connected to another supporting vehicle component (i.e. a  
9     component which would physically provide support to the dual purpose electrical and  
10    antenna system in its use state). For example, the dual purpose electrical and antenna  
11    system could be mounted to the interior surface of the instrument panel substrate, a  
12    rear package shelf, a pillar trim panel, a headliner, an exterior cowl panel, etc.

13            In sum, several advantages are now possible via the use of the present  
14    invention, which are summarized below:

- 15            • an antenna system that is upwardly facing through the front window of the  
16              vehicle thereby providing maximum exposure to radio signal reception;
- 17            • the reduction in cost necessary to manufacture window glass antennae;
- 18            • the elimination of exterior antenna components;
- 19            • the elimination of costly antenna leads between the radio and current  
20              antenna systems;
- 21            • the elimination of antenna cable installation in vehicular assembly plants;
- 22            • the elimination of the need to seal external antenna components against the  
23              environment;

- 1           • the elimination of conventional wire harnessing in instrument panel
- 2           assembly;
- 3           • the elimination of wire harness assembly requirements;
- 4           • the reduction in warranty claims as related to wire harness and antenna
- 5           system performance;
- 6           • the reduction in cost of the electrical system;
- 7           • the reduction in weight of the vehicular electrical system;
- 8           • increased usable space in the instrument panel assembly; and
- 9           • the elimination of associated wire harness and antenna connectors.

10           Finally, in the context of the present invention, it can be appreciated that the  
11 specific antenna/circuitry combination for the instrument panel can be customized for  
12 each vehicle dependent upon vehicle design requirements. In addition, once the  
13 vehicle design is considered, the antenna/circuitry combination herein can itself be  
14 adjusted to maximize its broadband characteristics so that it will efficiently receive  
15 and/or transmit as necessary. In such regard, antenna length can be conveniently  
16 varied across the instrument panel surface in length/width and/or depth from the  
17 surface to optimize transmission and reception functionality.

18

We claim:

1. A trim panel for a vehicle containing a vehicular antenna system comprising:

a substrate;

an outer skin;

a foam disposed between said substrate and said outer skin;

an antenna/circuitry system located on the upper surface of said substrate in contact with said foam, said antenna/circuitry system comprising printed circuitry comprising an insulating base layer with an upper and lower surface, an electro-conductive antenna layer on the upper surface of said base layer, an electro-conductive circuit layer on the lower surface of said base layer, said electro-conductive circuit layer providing a source of electrical current for said vehicle; and

a first insulating cover layer on the upper surface of said antenna electro-conductive layer and a second insulating cover layer on the lower surface of said electro-conductive circuit layer.

2. The trim panel of claim 1 wherein said antenna layer comprises copper.

3. The trim panel of claim 1 wherein said flexible circuit layer comprises copper.

4. The trim panel of claim 1 wherein said insulating base layer comprises a polyimide.

5. The trim panel of claim 1 wherein said first and second insulating cover layers comprise a polyimide.

6. The trim panel of claim 1 wherein said electro-conductive antenna layer and said electro-conductive circuit layer are connected to a radio in said vehicle.

7. The trim panel of claim 6, wherein said electro-conductive antenna layer has an impedance, and said radio has an impedance, and said electro-conductive antenna layer is configured to match said radio impedance.

8. The trim panel of claim 1 wherein said electro-conductive antenna layer is configured to receive one or more of a radio transmission, a cellular phone frequency, a global positioning transmission, a locking/unlocking signal for said vehicle, a keyless ignition frequency and/or a wireless internet access transmission.

9. A trim panel for a vehicle containing a vehicular antenna system comprising:

a substrate;

an outer skin;

foam disposed between said substrate and said outer skin;

an antenna/circuitry system located on the upper surface of said substrate in contact with said urethane foam, said antenna/circuitry system comprising an insulating base layer including upper and lower surfaces and an electro-conductive antenna layer on the upper surface of said base layer and an electro-conductive circuit layer on said lower surface of said base layer.

10. The trim panel of claim 9 wherein said antenna layer comprises copper.

11. The trim panel of claim 9 wherein said circuit layer comprises copper.

12. The trim panel of claim 9 wherein said insulating base layer comprises a polyimide.

13. The trim panel of claim 9 including a first insulating cover layer on said antenna electro-conductive layer and a second insulating cover layer on said electro-conductive circuit layer.

14. A trim panel for a vehicle containing a vehicular antenna system comprising

a substrate containing a recessed portion;

an outer skin;

a foam disposed between said substrate and said outer skin;

an antenna/circuitry system located within said recessed portion of substrate and covered by said urethane foam;

said antenna/circuitry system comprising an insulating base layer including upper and lower surfaces and an electro-conductive antenna layer on the upper surface of said base layer and an electro-conductive circuit layer on said lower surface of said base layer.

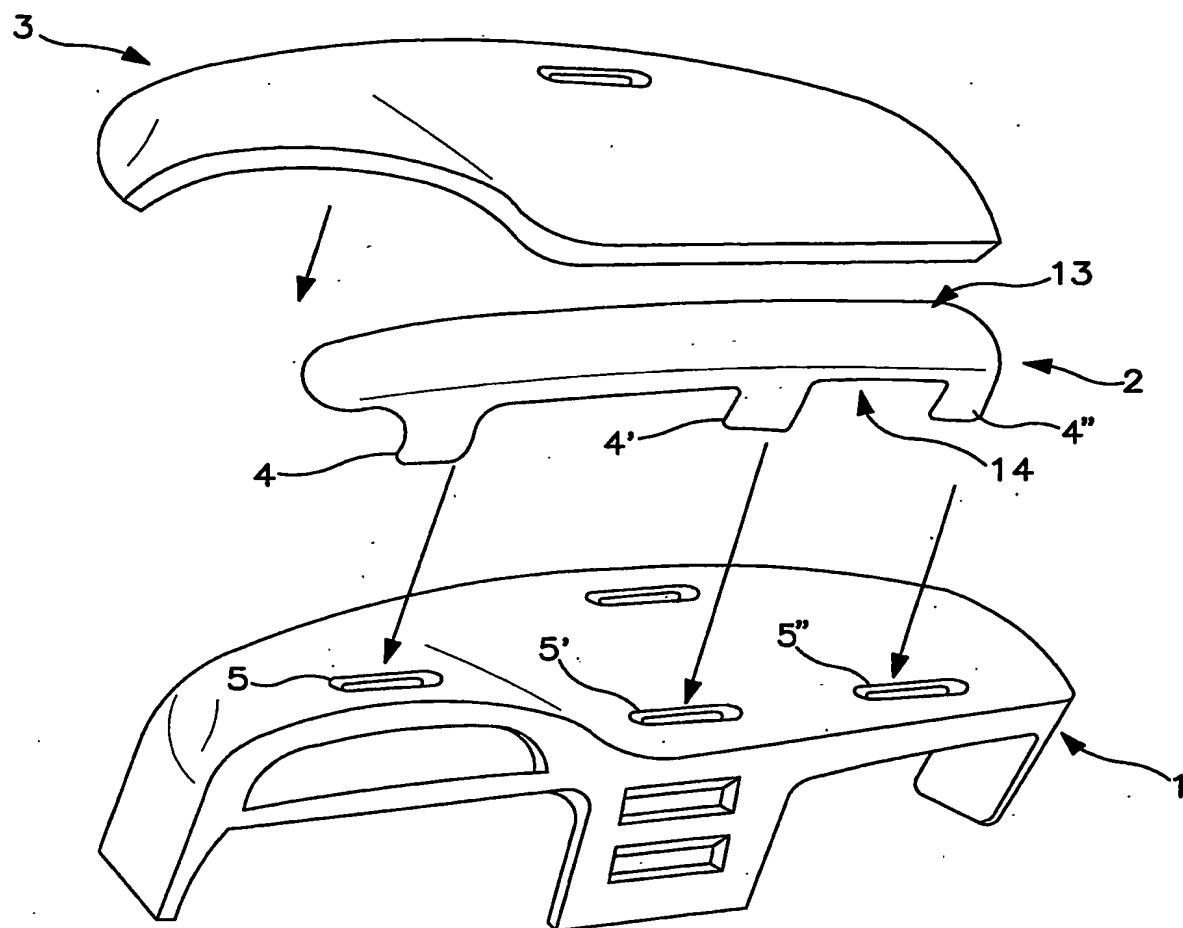


FIG. 1

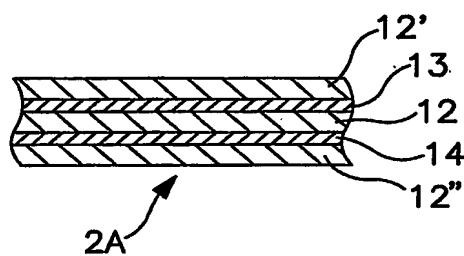


FIG. 2

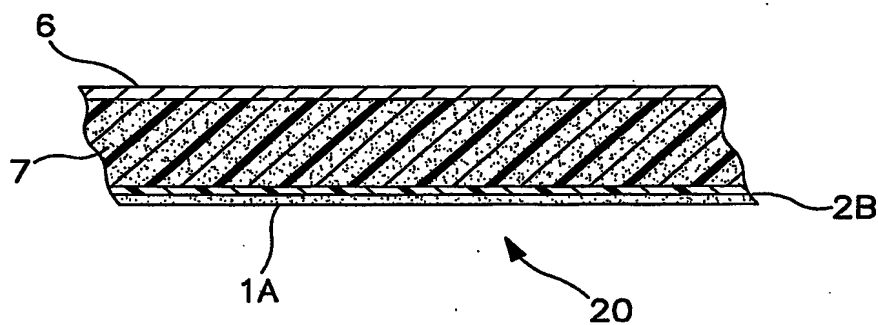


FIG. 3



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US01/48978

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC(7) : H01Q 1/32, 21/00, 11/12 ; G09G 5/00 US CL : 343/713, 711, 712, 742, 744, 745, 866, 867, 797, 749 According to International Patent Classification (IPC) or to both national classification and IPC																						
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) U.S. : 343/713, 711, 712, 742, 744, 745, 866, 867, 797, 749 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched NONE Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) NONE																						
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>																						
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																				
Y	US 6,144,343 A (FURUYA et al.) 07 November 2000 (07.11.2000), entire document.	1-14																				
Y	US 3,896,448 A (KILLEN et al.) 22 July 1975 (22.07.1975), entire document.	1-14																				
Y	US 5,402,134 A (MILLER et al.) 28 March 1995 (28.03.1995), entire document.	1-14																				
Y	US 5,625,371 A (MILLER et al.) 29 April 1997 (29.04.1997), entire document.	1-14																				
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.																						
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